

# State of the Ecosystem 2020: Response Memo

11 March 2020

## Introduction

In the table below we summarize all comments and requests with sources. The Progress column briefly summarizes how we responded, with a more detailed response in the numbered Memo Section. In the Progress column, “SOE” indicates a change included in the report(s).

Request	Source	Progress	Memo Section
Formal response to requests	Both Councils	This response memo.	Introduction
Consider report card like Alaska’s	Both Councils	SOE summary bullets (page 1).	1
Include summary visualization	Both Councils	SOE infographics (page 1-2).	2
Include uncertainty estimates for all indicators	Both Councils	SOE survey biomass uncertainty included; feedback requested for other indicators.	3
Include Downeast ME (Scotian Shelf EPU)	NEFMC	SOE survey biomass now includes most of downeast ME; human dimensions include downeast ME.	4
Link zooplankton abundance and or community composition to fish condition	NEFMC	SOE page 2 research spotlight.	5
Ocean acidification information	Both Councils	Work in progress to develop baseline and monitoring.	6
Gulf Stream Index/Labrador current interaction	Both Councils	SOE Labrador current and Gulf Stream indices now included in both reports.	7
Include source for PP estimates (satellite vs in situ)	NEFMC	SOE clarified that all PP estimates are from satellite.	8
Shellfish growth/distribution linked to climate (system productivity)	MAFMC	Project with R. Mann student to start late 2020.	9
Estuarine condition relative to power plants and temp	MAFMC	Inadequate resources to address this year.	10
Frequency and occurrence of warm core rings	MAFMC	SOE added new indicator.	11
Cold pool index	MAFMC	SOE added new indicator.	12
Nutrient inputs and water quality near shore	MAFMC	SOE Chesapeake update; summary of data from National Estuarine Research Reserve network started, example info included here.	13
Link environmental and social, economic indicators	NEFMC	SOE added new PP required, habitat and wind overlap, page 2 conceptual model.	14
Quantitative overlap of wind area and habitat and fishing areas	MAFMC	SOE added new indicator for habitat and wind overlap, wind overlap with fisheries for next round.	15
Include links to Social Science websites	NEFMC	SOE link included in both reports.	16
Management complexity	MAFMC	Project started by summer student in 2018, needs further analysis.	17
South Atlantic Council managed species represented in recreational indices	MAFMC	SOE revised indicator and noted change in report.	18
Add social elements from overview conceptual model to NE conceptual model	NEFMC	Older general conceptual model replaced by specific links between indicators in report.	19

(continued)

Request	Source	Progress	Memo Section
Avg. weight of diet components by feeding group, mean stomach weight across feeding guilds	Both Councils	Stomach fullness analysis started–species level; feedback requested.	20
North Atlantic Right Whale calf production indicator	NEFMC	SOE added new indicator.	21
Distinguish managed species in report	NEFMC	SOE Council managed species separated in landings figures.	22
Marine Mammal consumption	MAFMC	SOE added discussion of seal diets.	23
Small pelagic abundance	MAFMC	SOE have survey planktivore time series but would like to improve; see also SOE forage energy density.	24
Young of Year index from multiple surveys	MAFMC	SOE fish production from NEFSC trawl; feedback requested on how to expand.	25
Biomass of sharks	MAFMC	HMS provided landings for 3 years and working on full time series, still looking for source of biomass data.	26
Diversity metric for NEFSC trawl survey	NEFMC	Need to reconcile different survey vessel catchabilites or split by vessel.	27
Ecosystem risk score	MAFMC	SOE PP required, marine heat waves are steps towards this; feedback requested for other desired analyses.	28
Inflection points for indicators	Both Councils	SOE warm core rings; general analysis of combined indicators initiated but not yet finished.	29

## Responses to comments

### 1 Report Card

Both Councils asked for a summary “report card” similar to that used in Alaska [1]. The first page of each of this year’s SOE reports summarizes the key messages with icons showing the message theme (e.g., commercial fisheries, fishing communities, forage species, system productivity, etc). At present, we synthesized key findings on both existing and new indicators. We welcome suggestions for indicators that should always be tracked in this section, and for further refinements to make this summary more useful.

### 2 Summary Visualization

Both Councils asked for a summary visualization. The first page of each SOE report uses icons developed to help visualize different report components. The second page of each SOE report has both a map visualizing the key oceanographic features mentioned in the report along with fishing communities, and a conceptual model visualizing potential linkages between report indicators. The conceptual model is discussed further under point 5 below.

### 3 Uncertainty Estimates

Both Councils asked for uncertainty estimates to be included with indicators. As a first step, we included survey design-based uncertainty estimates<sup>1</sup> for all surveys where we had haul specific information (all but the inshore ME-NH survey). Including this uncertainty led to a different approach to the data, looking for true departures from expected stable dynamics at the functional group level, and provided insight into which trends were potentially noteworthy. Survey biomass uncertainty is included in each SOE (p. 15-16 MAFMC and p. 16-19 NEFMC).

We experimented with a model-based estimate of uncertainty for survey biomass which accounts for both spatial and temporal sources (VAST; [2]). The results are promising (Fig. 1), and may serve not just as a biomass indicator but also an indicator of distribution shifts for species and functional groups. This method can also potentially combine the inshore and offshore surveys into a single analysis. If the SSCs and Councils consider this approach promising, we will persue it further for next year.

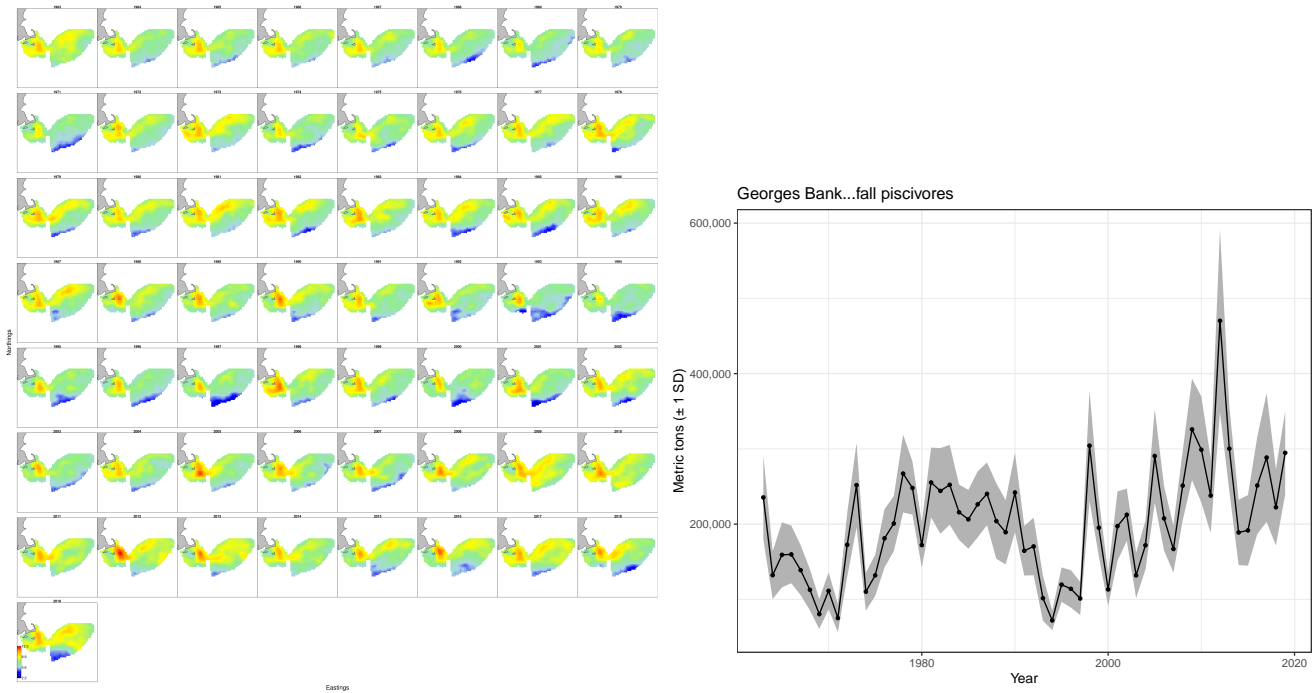


Figure 1: Georges Bank piscivoves biomass and uncertainty as estimated by the VAST model.

Some indicators (e.g. total landings) may have uncertainty which is difficult to calculate (e.g. based on unknown reporting errors). Many other current indicators do not have straightforward uncertainty calculations (e.g. diversity indices, anomalies) so we welcome suggestions from the SSC and Council to guide estimation for future reports.

### 4 Downeast Maine

The NE SSC asked to include downeast ME in future reports, because the Scotian Shelf EPU which includes downeast ME has not been included in previous reports. We felt it was inappropriate to report on the Scotian Shelf EPU, which includes Canadian waters and is an incomplete portion of the full Soctian Shelf. However, this year we recalculated survey biomass using an updated strata set that includes much of downeast ME for the NEFSC (Fig. 2; p. 16-17 NEFMC SOE). Strata were included within an EPU where at least 50% of their area was located. The inshore strata not included in the NEFSC trawl survey biomass are represented in the ME-NH survey (p. 20 NEFMC SOE) Further, fishery catch and revenue data, fishing community data, and recreational indicators have

<sup>1</sup><https://noaa-edab.github.io/tech-doc/survdat.html>

always included downeast ME because both fishing statistical areas and human community data include all of ME. Therefore, fishery and fish biomass information reflects much of the area.

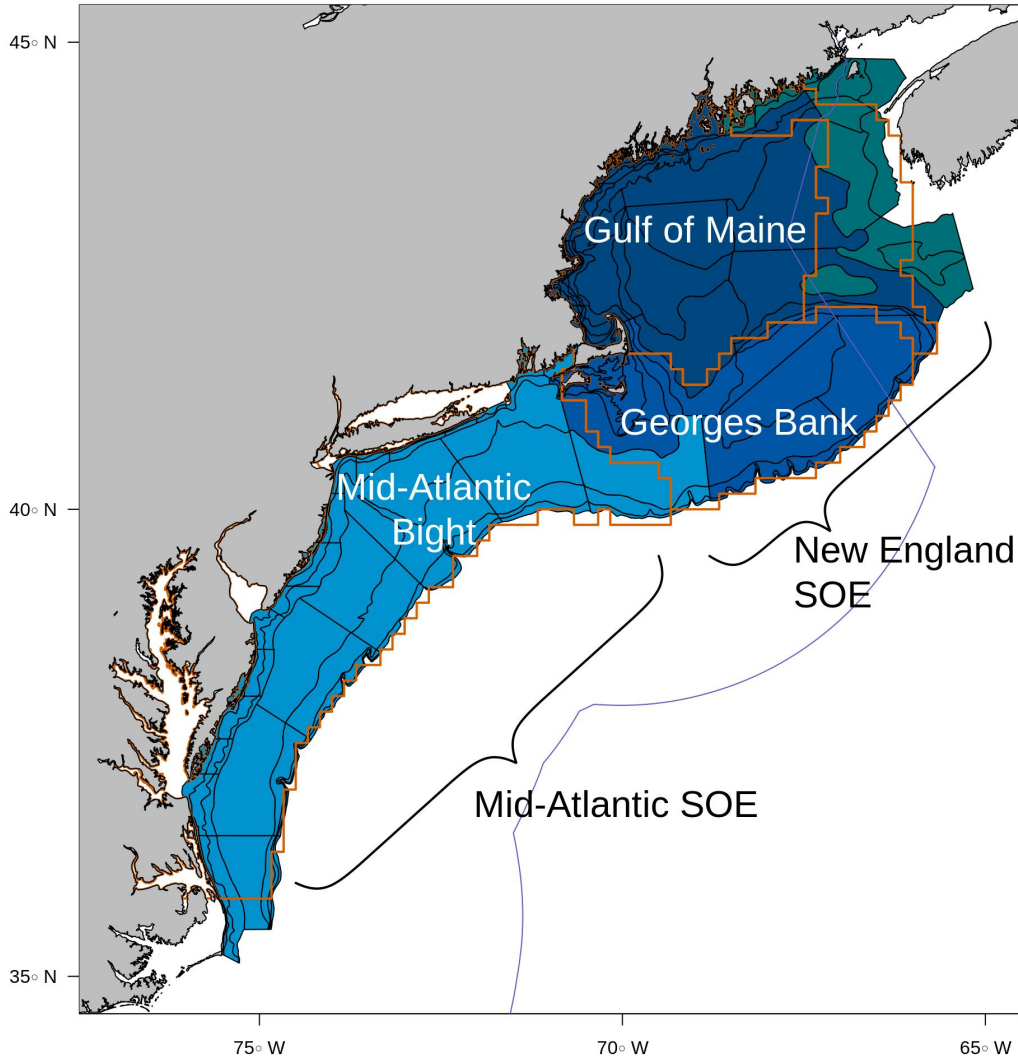


Figure 2: Survey strata mapping to EPUs for biomass estimates

Oceanographic indicators (surface and bottom temperature, phytoplankton, zooplankton) remain at the EPU level. The EPUs were defined based on these characteristics<sup>2</sup> so we are hesitant to alter them for these indicators without a more thorough examination of the EPU definitions in general.

## 5 Link Zooplankton, Fish Condition

Both Councils have been interested in ecosystem energy flow and how changes in ecosystem productivity link to fishery production. In particular, the NE SSC asked about further links between zooplankton abundance and or community composition to fish condition. Research was initiated during 2019 evaluating statistical relationships between environmental indicators including temperature, depth, and zooplankton community composition and

<sup>2</sup><https://noaa-edab.github.io/tech-doc/epu.html>

fish condition. Initial results are noted in each SOE (p. 16-17 MAFMC and p. 20-21 NEFMC). Further work is ongoing to link more of the indicators in the report using both statistical analysis and potentially structural equation modeling as noted on p. 2 of each SOE under “Research Spotlight.” This conceptual model shows the full range of potential linkages, but we plan to start with a subset of linkages (Fig. 3). In particular, potential linkages between zooplankton and forage fish energy content (p. 18 MAFMC and p. 23 NEFMC) may also be explored in the upcoming years.

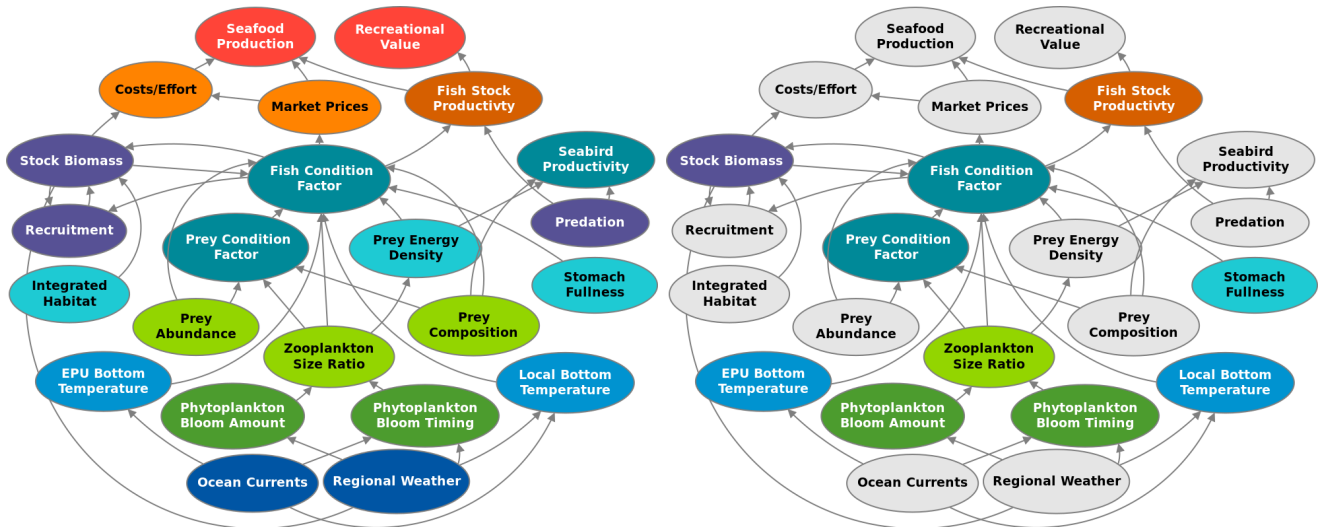


Figure 3: Full set of hypothesized relationships between SOE indicators related to fish condition (left) and subset to be investigated first (right).

## 6 Ocean Acidification

Both Councils asked for information on ocean acidification (OA). In 2019, NOAA reviewed available OA information and is now finalizing a research plan<sup>3</sup> to address OA comprehensively. Unfortunately, this synthesis was not available in time to include in the 2020 SOE.

The main message of this forthcoming report is that we don’t have much of a time series of OA monitoring data for our region yet, but we have been (and will continue) collecting data in the Northeast and that NOAA sees OA monitoring as a priority. There are three main research objectives for 2020-2029 outlined in the report:

1. Document and predict change via monitoring, analysis, and modeling.
2. Characterize and predict biological sensitivity of species and ecosystems.
3. Understand human dimensions and socioeconomic impacts of OA.

Specific work is in progress now and should be available for future SOE reports, including:

- Aleck Wang (WHOI) and Chris Melrose (NEFSC) are working on climatology of spatial and seasonal patterns of carbonate chemistry parameters on the Northeast U.S. Continental Shelf, which will form a critical baseline for future OA indicators.
- Grace Saba (Rutgers) is the lead PI on a new project which is using gliders to characterize OA conditions and to validate/improve OA models for the region.
- There is ongoing experimental work being conducted at the NEFSC Milford lab that we could include if the information is relevant

<sup>3</sup>[https://sab.noaa.gov/sites/SAB/Meetings/2019\\_Documents/Dec\\_Meeting/2020%20OA%20Research%20Plan%20DRAFT%20External%20Review.pdf](https://sab.noaa.gov/sites/SAB/Meetings/2019_Documents/Dec_Meeting/2020%20OA%20Research%20Plan%20DRAFT%20External%20Review.pdf)

Until a climatology and time series of OA measurements is available for comparison, we can include other information on OA in the SOE as it becomes available. We welcome feedback and suggestions from the SSC and Council on what information would be most useful.

## **7 Gulf Stream and Labrador Current**

Both Councils were interested in large scale ocean current interactions and requested additional information on the Gulf Stream Index and Labrador current. We have expanded this section and included information on both Gulf Stream warm core rings (see point 11) and on the decreasing proportion of Labrador Current water entering the Gulf of Maine in both SOE reports this year (p. 20-22 MAFMC and p. 24-26 NEFMC).

## **8 Primary Production Source**

The NE SSC asked that we include sources for primary production estimates (satellite vs in situ). We have noted in the SOE that primary production and chlorophyll estimates are satellite-derived (p. 25 MAFMC and p. 31 NEFMC), and continue to include full methods in our technical documentation<sup>4</sup>.

## **9 Shellfish Growth**

The MAFMC requested that we investigate how shellfish growth and distribution information could be linked to climate indicators and possibly ecosystem productivity. While this request was beyond our capacity to address this year, we are working with Dr. Roger Mann to host his student working on shellfish growth at NEFSC and to facilitate integration of SOE climate indicators with this work later this year or early next.

## **10 Power Plants**

The MAFMC requested that we investigate estuarine condition relative to power plants and plant-driven changes in water temperature. This request was beyond our capacity to address this year. However, we have initiated work on estuarine water quality in general (see point 13).

## **11 Warm Core Rings**

The MA SSC requested information on the frequency and occurrence of Gulf Stream warm core rings. We have added an indicator based on [3], [4], and [5] to both SOE reports (p. 20-21 MAFMC and p. 24-25 NEFMC). We welcome further comments on the utility of this new indicator.

## **12 Cold Pool Index**

The MA SSC requested a cold pool index. We have added an indicator of cold pool temperature to the MAFMC SOE report, because the cold pool was considered most relevant to the MAB EPU (p. 23 MAFMC). However, if the NEFMC is interested in this index (because some managed species such as winter flounder occupy this habitat) we can include it in future NEFMC SOE reports. We welcome further comments on the utility of this new indicator.

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<sup>4</sup><https://noaa-edab.github.io/tech-doc/chl-pp.html>

### 13 Estuarine Water Quality

The MAFMC requested information on nutrient inputs and water quality near shore and in estuaries. While the Chesapeake water quality index from the 2019 report was not yet updated by the contributor, we included information on the Chesapeake Bay low salinity event in 2018-2019 with notes on how it affected Chesapeake Bay living resources in the SOE (p. 19-20 MAFMC).

This year we started a collaboration with the National Estuarine Research Reserve (NERR) network to assemble information. Here we provide examples of the types of information available and ask for feedback on what type of information would be most useful.

There are NERRs all around the US (Fig. 4), so the first decision is which ones to include. A reasonable starting point might be all of the NERRs from ME to NC, but other locations may be of interest. Then, status for a certain indicator could be mapped across all of the selected NERRs as in Fig. 4.

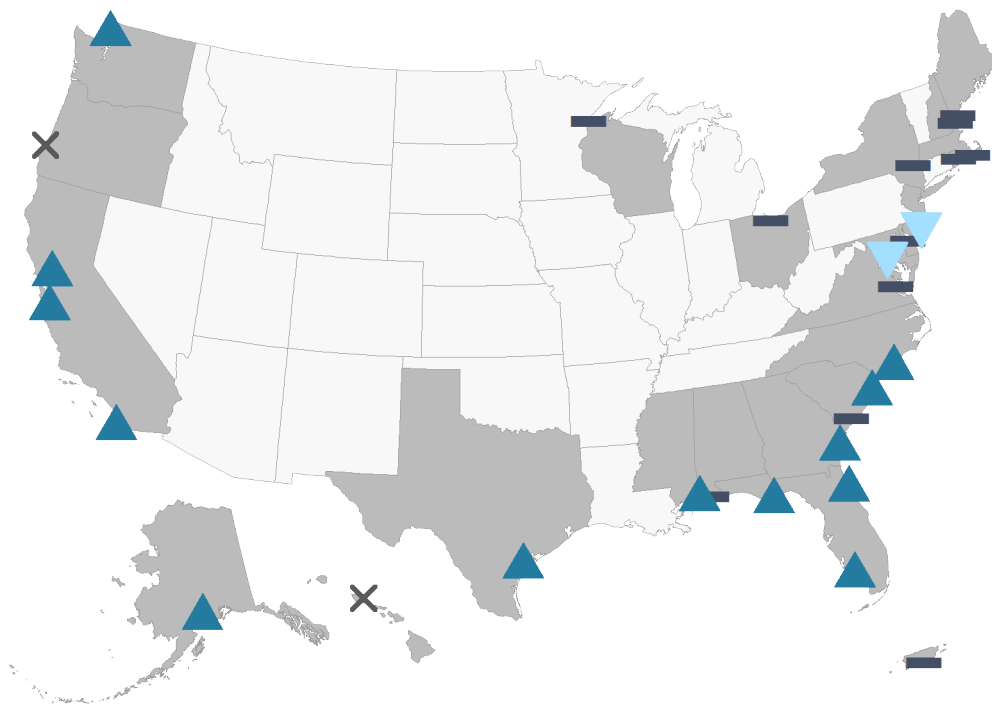


Figure 4: National Estuarine Research Reserve locations in the US, with trend indicators for an example metric: Triangle pointing up = increasing trend; Triangle pointing down = decreasing trend, Flat line = no trend.

Within a particular NERR there may be several sampling locations (Fig. 5), so the next decision would be whether to include many stations or a subset of stations representing certain conditions (or having the longest time series).



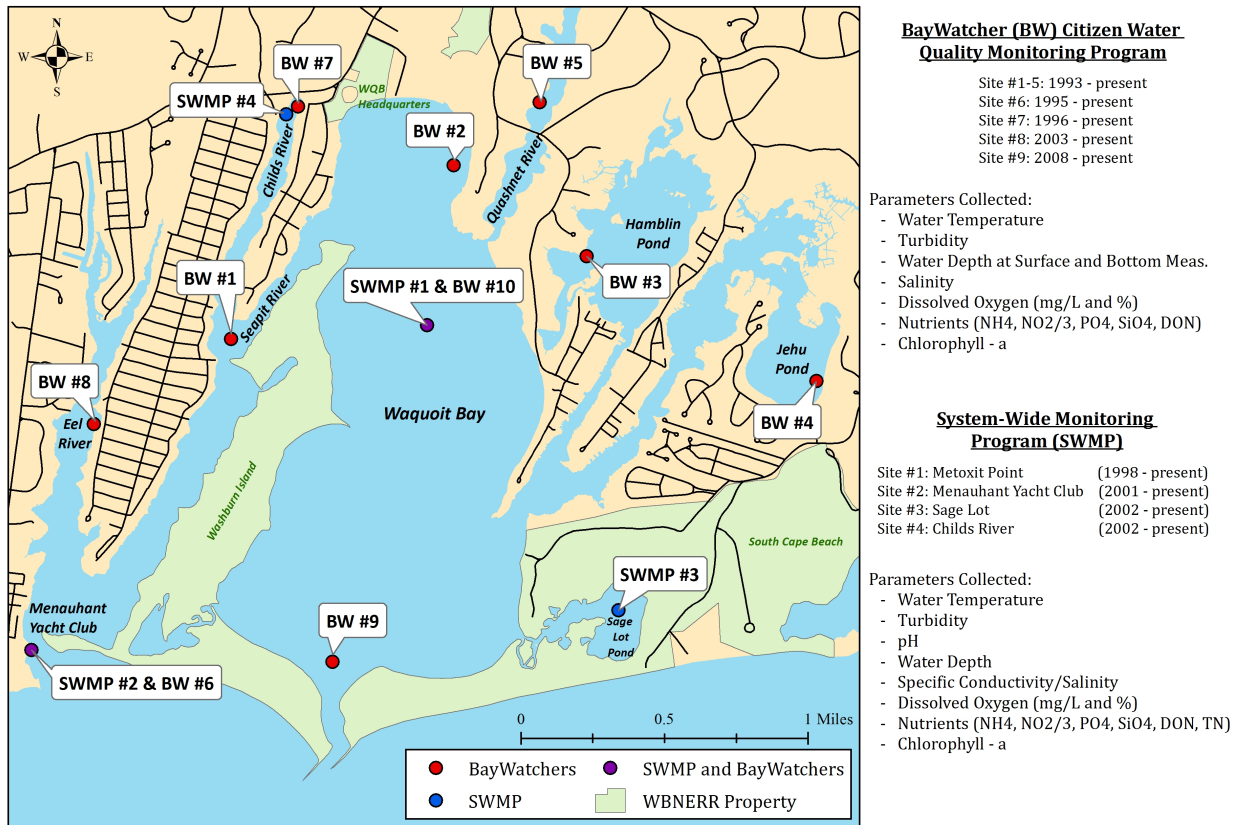


Figure 5: Waquoit Bay National Estuarine Research Reserve map with sampling locations.

At each station several types of data are collected, so the next decision is which type of information is most useful for the Councils? For example, multiple indicators could contribute to water quality overall in an area, and could be annual or seasonal (Fig. 6), or a single indicator of nutrient input could be of interest across multiple areas (Fig. 7).

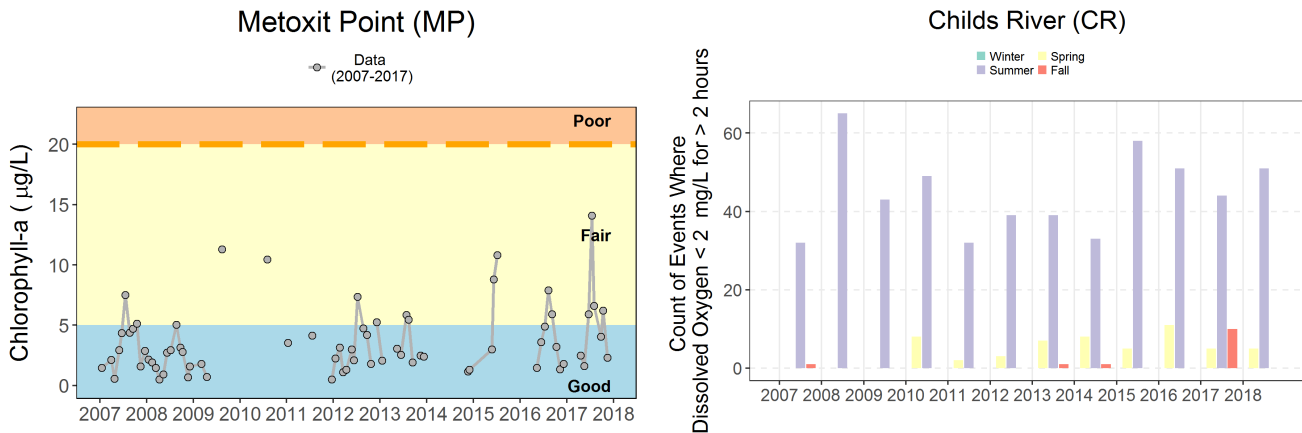


Figure 6: Multiple water quality attributes.



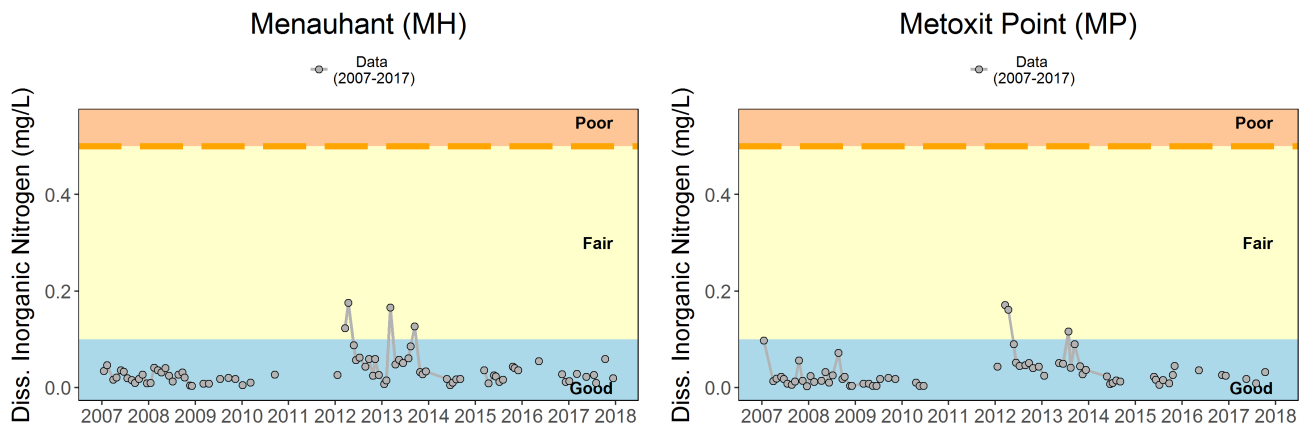


Figure 7: Dissolved Inorganic Nitrogen (DIN) in two locations.

Finally, thresholds for water quality would need to be reviewed (Fig. 7). Several exist and could be used by the Council depending on the ultimate goal for having the indicator.

## 14 Link Environment and Society

The NEFMC asked for more linkages between environmental and social and economic indicators in the SOE. Two new indicators and the research spotlight linking environmental indicators, fish condition, and fishery economic indicators highlighted under point 5 address this request. The first new indicator places commercial fishery landings in the context of ecosystem productivity by calculating the primary production required to support landings; it is described in detail below. The second new indicator calculates the probability of occupancy of wind lease areas based on habitat modeling; it is described in detail in point 15.

### Primary production required (PPR)

This indicator is included in both SOEs (p. 3-4 MAFMC and NEFMC). It is defined as

$$PPR_t = \sum_{i=1}^{n_t} \left( \frac{\text{landings}_{t,i}}{9} \right) \left( \frac{1}{TE} \right)^{TL_i-1}$$

where  $n_t$  = number of species in time  $t$ ,  $\text{landings}_{t,i}$  = landings of species  $i$  in time  $t$ ,  $TL_i$  is the trophic level of species  $i$ ,  $TE$  = Trophic efficiency. The PPR estimate assumes a 9:1 ratio for the conversion of wet weight to carbon and a constant transfer efficiency per trophic level.

We have explored the index in the following ways. Using:

- A global transfer efficiency of 15% for all species.

This gives comparable estimates to methods used in Figure 7.3 of the 2009 Ecosystem Status Report<sup>5</sup> that applied a combination of transfer efficiencies calculated from EMAX food web models<sup>6</sup>. While many studies use a 10% rule of thumb, that is an approximation as well. One adaptation would be to use a different transfer efficiency for the first level. eg.  $\left( \frac{1}{TE_1} \right) \left( \frac{1}{TE_2} \right)^{TL_i-2}$ . Whatever choices are made, the sensitivity of the index to such changes should be examined.

<sup>5</sup><https://www.nefsc.noaa.gov/publications/crd/crd0911/crd0911.pdf>

<sup>6</sup><https://www.nefsc.noaa.gov/publications/crd/crd0615/crd0615.pdf>

- *Primary production not lagged with landings.*

This is probably not realistic. You wouldn't expect to see changes in the landing the same year as changes in primary production. This needs to be explored, either using specific lags in time (which may prove problematic since species lower on the food chain will be effected by shorter lags in time versus species higher up the chain) or by adopting some weighted scheme.

- *A threshold of 80% for landings.*

It would be a good idea to explore the sensitivity of the index for other threshold levels. Of course the higher the threshold used would imply that less common species will then contribute to the index.

- *Combined vertebrates and invertebrates.*

The landings in some of the EPU's are dominated by invertebrates (Lobster, Clams) which may play a significant part in driving this index. Creating two additional indices, one for vertebrates and one for invertebrates may be an interesting avenue. This will of course imply the inclusion of many other lesser caught species into the index. It will also involve partitioning the landings into vertebrates and invertebrates.

*Other comments*

- Some classifications in the commercial fisheries database are not at the species level. Some are Genus, Family or even higher orders, some are just general unclassified. eg. (DOGFISH, UNC, FLATFISH, Argentinidae). Most of these cases are associated with lower landings. However if we increase the threshold and/or split landings into vertebrates and invertebrates we will encounter more of these classifications. They will need to be assigned a trophic level which may cause complications and/ or subjective decision making.
- It is possible for species to drop out of the top x% of the landings and be replaced by other species with a similar trophic level and the index will be somewhat insensitive to this (Fig. 8). The mean trophic level would also be insensitive to such changes. This may or may not be of concern, but it may be worth looking into how often this occurs.

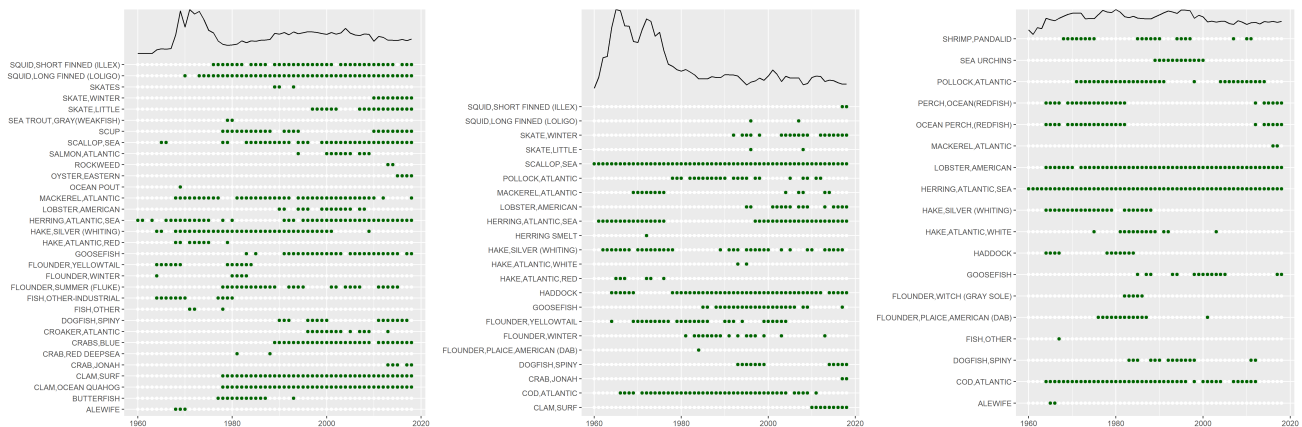


Figure 8: Species included in 80% of landings for each year in the Mid-Atlantic Bight (left), Georges Bank (center), and Gulf of Maine (right).

We welcome feedback for approaches to refine this indicator.

## 15 Wind Energy Habitat Overlap

The MAFMC requested an index of quantitative overlap of wind energy lease areas and fisheries, in particular to update the EAFM risk assessment (Other ocean uses risk element). A list of species with the highest probability of occupancy in the current and proposed wind lease areas based on habitat modeling is included in both SOEs (p. 8-9

MAFMC and p. 9 NEFMC). This indicator can be refined to meet the needs of both Councils. In future reports we plan to include the overlap of current fisheries with wind lease areas as well.

## **16 Other Social Science Indicators**

The NE SSC asked that we include links to NMFS Social Science indicator websites. These links have been included in both reports (p. 8 MAFMC and p. 9 NEFMC).

## **17 Management Complexity**

The MAFMC asked for indicators of management complexity for use in the EAFM risk assessment. An NEFSC summer student started work on this in 2018, but we have lacked capacity to finish the project since then. If resources allow we will continue the project, and guidance for further indicator development is welcome.

## **18 SAFMC and ASMFC Species**

The MAFMC asked that South Atlantic Council and Atlantic States Marine Fisheries Commission-managed species be represented in recreational catch diversity indices. This has been done and the updated indicator is included in both SOE reports (p. 7-8 MAFMC and NEFMC).

In addition, NEFSC survey data was analyzed to determine if South Atlantic Council-managed species have become more common in the survey over time. This indicator has also been included in both SOE reports (p. 14-15 MAFMC and p. 15-16 NEFMC).

## **19 Conceptual Model Social Elements**

The NEFMC requested that social elements from the overview conceptual model shown in presentations be added to the New England conceptual model included in the printed SOE report. While this would be a useful update, all of the previous conceptual models have been replaced by different summary visualizations requested by the Councils (see points 1 and 2).

## **20 Fish Diet Indicators**

Both Councils were interested in indicators related to fish diet data. For example, average weight of diet components by feeding group, and mean stomach weight across feeding guilds were mentioned. We initiated exploratory analysis of diet information this year, and present examples of the types of information available to seek feedback on how the Councils would like indicators developed further.

On NEFSC surveys, most stomach estimates are taken as a volume measure, but there is a standard conversion included in the diet database that gives an approximate stomach weight. This estimated stomach weight was used to calculate stomach fullness (a ratio of stomach weight to fish weight for non-empty stomach samples). Stomach fullness may be a better measure than absolute stomach weight if combining across species into a feeding guild, otherwise big animals with heavier stomachs will dominate the index. Here, stomach fullness was expressed as an annual anomaly for each species in each region. This shows which species have adequate data for inclusion in a time series, and suggests there are not obvious common stomach fullness anomalies across species. We welcome suggestions to clarify methods and objectives for fish stomach data indicators.

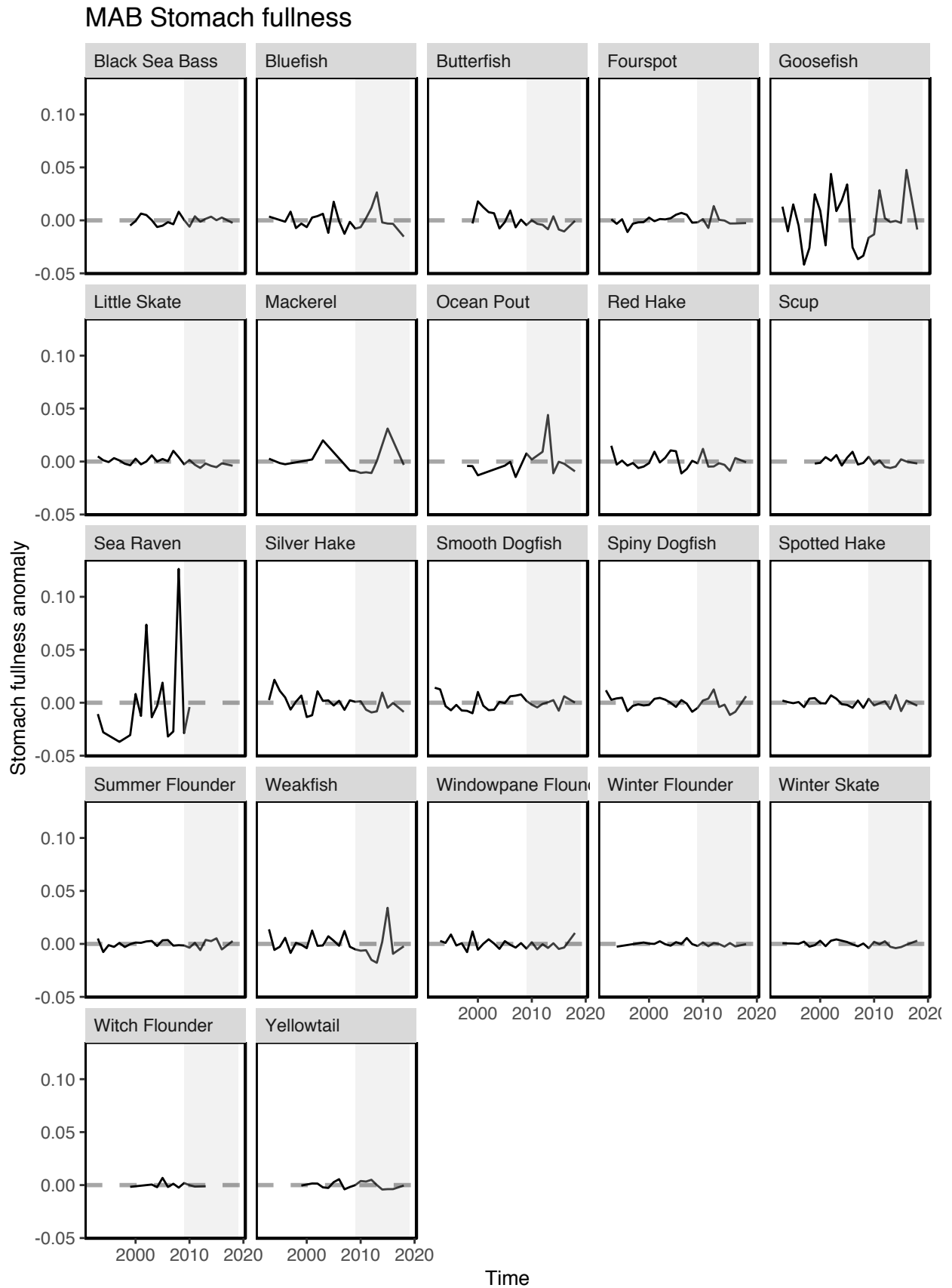


Figure 9: Stomach fullness anomaly in the Mid-Atlantic Bight.

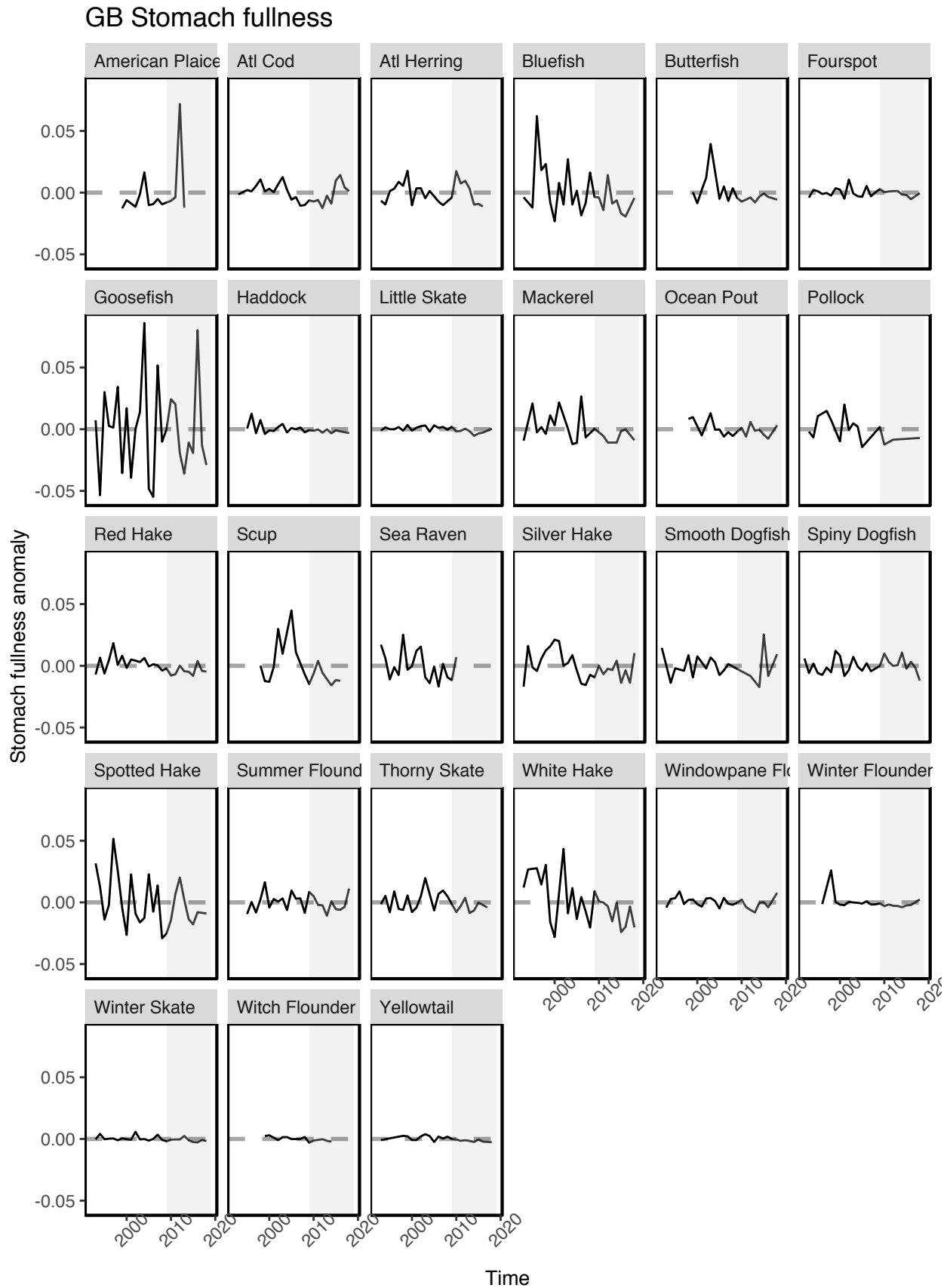


Figure 10: Stomach Fullness Anomaly in New England.

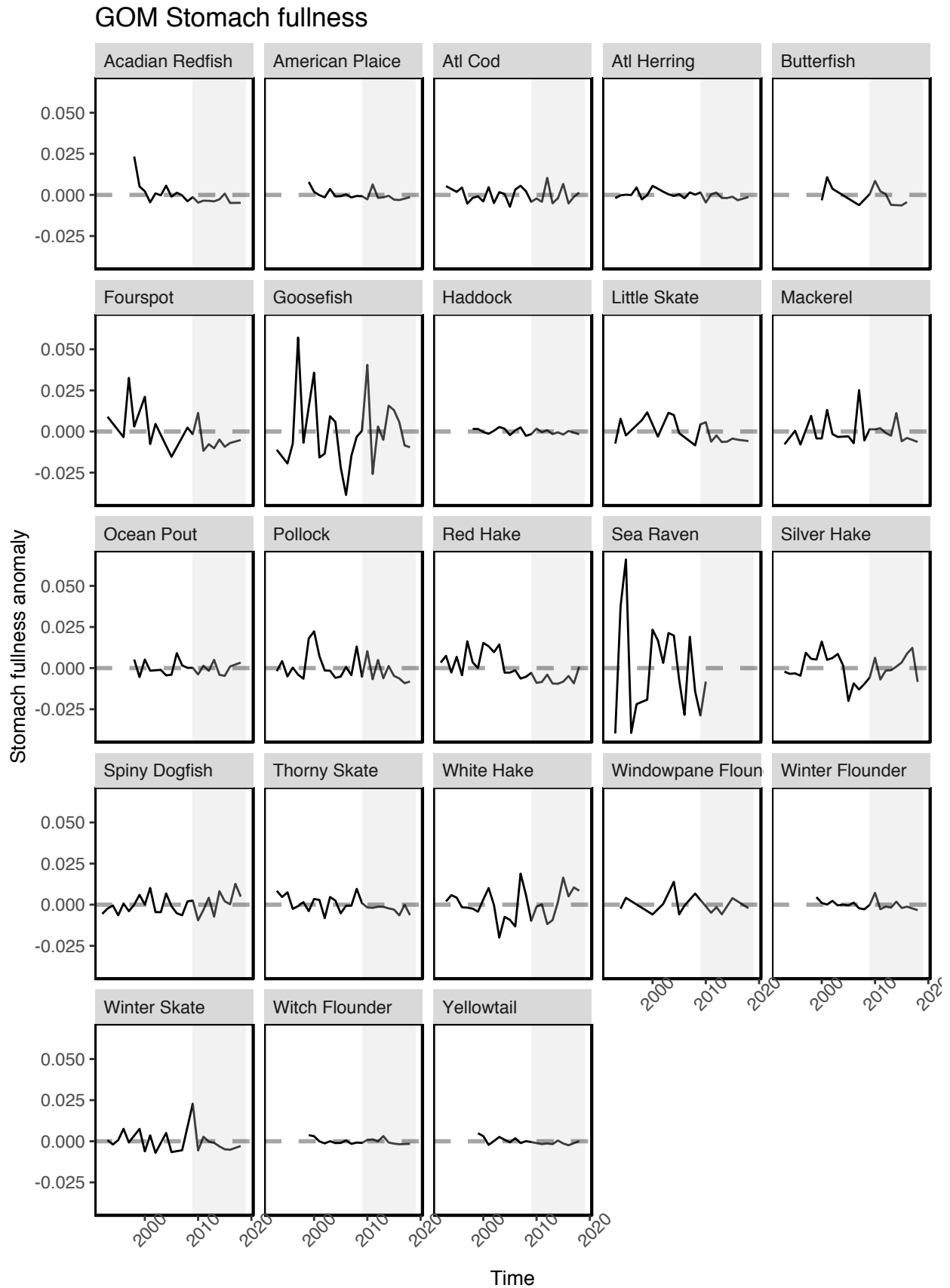


Figure 11: Stomach Fullness Anomaly in New England.

## 21 Right Whale Calves

The NEFMC requested a North Atlantic Right Whale calf production indicator. This indicator has been added to both SOE reports (p. 10-11 MAFMC and NEFMC).

## 22 Distinguish Managed Species

The NEFMC requested that managed species be distinguished in the report. Both SOE reports summarize landings as a whole and by Council-managed species in aggregate (p. 4-5 MAFMC and p. 4-6 NEFMC). A table listing which species are managed by which entity is included in each SOE report (Table 4 in both reports). Status of Council-managed species is reported in each SOE (p. 30 MAFMC and p. 38 NEFMC) with jointly managed species indicated.

## 23 Marine Mammal Consumption

The MAFMC was interested in estimates of marine mammal consumption. While there have been no updated reports of total marine mammal consumption for the US Northeast Shelf ecosystem since 2015 [6], new diet studies are in progress. We included updated information on seal diets in both SOE reports (p. 11-12 MAFMC and NEFMC). Once completed, these diet studies combined with mammal population estimates could be used to update marine mammal consumption estimates.

## 24 Small Pelagic Abundance

The MAFMC requested indices of small pelagic abundance. While the SOE includes survey biomass estimates of planktivores (p. 15-16 MAFMC and p. 16-20 NEFMC), we would like to improve on these indices. Combining survey information using VAST models as described under point 3 may improve indices for small pelagics, but species not sampled by bottom trawl surveys remain problematic. We welcome feedback on other sources of information to address small pelagic abundance.

Forage energy content is another important consideration which may affect predators as much as fluctuations in abundance. This year we have included initial information on forage energy content in the SOE reports (p. 18 MAFMC and p. 23 NEFMC) which highlights the potential for seasonal and interannual variability in energy content. We plan to develop forage energy content indicators as this time series develops, and welcome feedback on how best to do so.

## 25 Young of Year Index

The MA SSC was interested in a young of year index from multiple surveys. We have included the fish productivity index in both SOE reports (p. 17-18 MAFMC and p. 21-23 NEFMC), which calculates the number of small fish per biomass of large fish of the same species from NEFSC surveys. This index has been reported previously to MAFMC, and intermittently to NEFMC. We recognize that this is not strictly a young of year index, and it is from a single survey. We seek guidance from the SSC on how to refine this index; would a similar index of small fish numbers to large fish biomass from the NEAMAP survey data be useful? Or would an index of young of year without biomass of larger fish be more useful? If so, how would we best combine species or select species for the index? And should we try to combine surveys or report them separately?

## 26 Shark Biomass

The MAFMC requested information on biomass of sharks, as fishermen had reported encountering more blacktip, spinner, and sandbar sharks each summer. We were able to obtain catch data from the Highly Migratory Species



group at NMFS Headquarters for the past 3 years, and the group is working on assembling a longer time series for future reports. We did not print the 3 year time series in the SOE reports, but visualizations are available along with other commercial landings<sup>7</sup>. To date, we have been unable to get biomass information on sharks at the coastwide level. We welcome suggestions for sources of this information.

## 27 Trawl Survey Species Diversity

The NE SSC requested a species diversity metric based on NEFSC trawl survey data. We have included such a metric in past reports (2017), but were concerned that apparent differences in diversity prior to and after 2008 may be driven by differences in survey vessels. While species-specific cpue and sizes have calibration coefficients between survey vessels, the number of species captured by the vessels has no known calibration coefficient.

We could calculate diversity indices for Albatross and Bigelow years separately to avoid this issue, and will do so if the Councils would find these separate indices useful.

## 28 Ecosystem Risk Score

The MAFMC requested work towards an ecosystem-level risk score. This system level score could augment information on individual risk elements already included in the MAFMC EAFM risk assessment, which is updated annually. Multiple indicators could be combined to form an integrated risk score (as discussed by the MAFMC Ecosystem and Ocean Planning Committee when evaluating this EAFM risk assessment), and many integrated scores have been suggested in the scientific literature. We seek further guidance on how best to develop an integrated ecosystem risk score for the MAFMC and NEFMC.

In the meantime, the primary production required to support landings introduced in this year's SOEs (p. 3-4 MAFMC and NEFMC, and see point 14 above) may contribute to an overall ecosystem risk score. While there is no established threshold for primary production required, fisheries would likely pose higher ecosystem risk if they require very high proportions of primary production. We welcome comments and suggestions from the Councils to continue this work.

Similarly, the new SOE marine heat wave indicator (p. 23-25 MAFMC and p. 28-31 NEFMC) may contribute to an overall ecosystem risk score from a climate/environmental perspective, as it measures the frequency of extreme temperature conditions in each EPU which pose risks to ecological and fishing communities. This could be integrated with existing climate vulnerability information and/or other report indicators to assess risk. Ultimately, the Council's objectives for this risk score will determine the components used.

## 29 Thresholds and Inflection Points

Both Councils have been interested in ecosystem-level thresholds and determining where indicators reach inflection points, suggesting changes in trends of concern. The SOEs include statistical analysis to determine where indicators have significant increasing or decreasing trends. However, based on a recent simulation analysis, we are confident in trend assessment only for time series of 30 years or more [7].

Where evidence is strong for shifts, we have looked at state changes rather than trends. The new Gulf Stream warm core ring indicator (p. 20-21 MAFMC and p. 24-25 NEFMC, and see point 11 above) shows a state change in warm core ring production based on a recent publication [5].

Some SOE indicators, such as the new marine heat wave cumulative intensity indicator in the Gulf of Maine (SOE Figure 35 on p. 29 NEFMC) have both significant trends and visually obvious shifts that could reflect a change in state for that indicator, which could be confirmed with further statistical analysis. Work is ongoing to determine statistically where shifts or change points across multiple indicators have occurred, but was not ready for inclusion in this year's reports. We welcome comments and guidance from the Councils on the types of analysis that would be most useful: change points for individual indicators, or across many indicators, or both?

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<sup>7</sup>[https://noaa-edab.github.io/ecodata/human\\_dimensions](https://noaa-edab.github.io/ecodata/human_dimensions)

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